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NPIC/R-47/62

## VERY LOW FREQUENCY ANTENNA NEAR Khabarovsk, USSR

## INTRODUCTION

This report, prepared under NPIC Project JN-247/61 in response to NSA Requirement A05/R-12-61A, describes the very low frequency (VLF) antenna near Khabarovsk which was identified from [REDACTED] photography of [REDACTED]. This installation was previously reported from [REDACTED] coverage as an unidentified installation. 1

The VLF antenna is located 9 nautical miles (nm) west of Khabarovsk at 48-29N 134-50E. It is situated only 3 nm south of the Trans-Siberian Railroad, therefore many of the features of this antenna would be visible from the train. The antenna is located over flat, swampy terrain within a rectangular fenced area. Just east of the antenna is a support area which includes barracks-like buildings, utility sheds, small-parts buildings, and similar structures.

Significant features of the antenna include (1) a very large overhead and ground capacitance system, (2) multiple tuning, and (3) simplicity.

The conclusions presented are as follows: (1) despite its large size and unique configuration, the antenna features readily recognizable principles of antenna engineering; (2) it has a fundamental design frequency of 29 kilocycles (kc); (3) the antenna gives the Soviets a Far East capability for communicating at very low frequencies with surface craft and submerged submarines; and (4) the antenna provides reliable communications in the difficult auroral zone.

All features that could be derived from the photography (Figure 1) have been mated to the known state of the art of low-frequency antennas to approximate how this antenna actually appears. 2 The limitations of the [REDACTED] photography, however, and the fact that no two VLF antennas can be exactly alike, allow no more than reasonable accuracy. Therefore, the concept presented in Figure 2 may not be entirely accurate.

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NPIC/R-47/62

**DETAILED ANALYSIS**

The VLF antenna near Khabarovsk can be described as being composed of six sections of suspended horizontal wires, or "flattop", and a buried grid of horizontal wires connected by vertical downleads. Each section is supported on each end by a guyed mast, and is supported in the center by a guyed "A" frame.



NPIC G-5630 (S 62)

FIGURE 1. VLF ANTENNA NEAR KHABAROVSK [REDACTED]

- 2 -

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NPIC/R-47/62

The overhead, or flattop, portion of the antenna is composed of six segments arranged parallel to one another. Each segment is one-eighth of a wavelength long and is made up of many strands of wire (item A, Figure 2). Each segment is suspended at its ends by two guyed masts (items B and B') and in the center by an "A" frame that is also guyed (item B''). The effective length of each section, 4,250 feet, is 250 feet less than the total distance between the towers because the insulators (items C and C') are estimated to be 125 feet from each mast. This estimate is based on information obtained from antenna engineering handbooks. 2/

#### Multiple Tuning Coils

The multiple tuning coils are shown at items D and D'. It is estimated that each section of the flattop is fed from one point only (item E).

#### Ground System

The ground system under the antenna (item F) is composed of a rectangular grid of buried cables so distributed that the system could be tapped at a great number of points.

#### Antenna Uncoupling Devices

An antenna uncoupling device (item H) is not mentioned in most antenna engineering handbooks, and the identification offered here is largely a matter of deduction.

#### Transmission Lines

Transmission lines are required to connect an antenna to the transmitter and are shown as item G. It is not apparent whether the transmitter near Khabarovsk is underneath the center of the antenna, as shown in

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NPIC/R-47/62

Figure 2, or whether it is in the support area. In either case, transmission lines would be less than one-eighth of a wavelength long and, therefore, not critical.

#### Fundamental Frequency

The Khabarovsk VLF antenna is a bent antenna, but it is not apparent from the photography whether it is an inverted L or a T. A section fed at the end (item E) would be an inverted L and a section fed at the center (item D) would be a T.

It is believed, however, that the sections are fed at item E, a conclusion that has been arrived at largely through mathematics.

If it is assumed that the VLF antenna is an inverted L and is end fed, a mathematical computation of its frequency can be made.

The effective length of one of the sections of the VLF antenna (item J) is approximately 4,250 feet (1,300 meters). It is estimated that each of these sections is equal to one-eighth of a wavelength. When these values are substituted in the frequency formula, and if this antenna follows the standard principle that frequency is a function of wavelength, the resulting equation is as follows:

$$\text{Frequency} = \frac{\text{Speed of light (meters per second)}}{\text{Fundamental wavelength (meters)}} = \frac{300,000,000}{8 \times 1,300} = 29 \text{ kilocycles per second}$$

Other formulas, based on ratios of empirical values for the length and height of the antenna, were used which indicated that the antenna could operate at much lower frequencies.

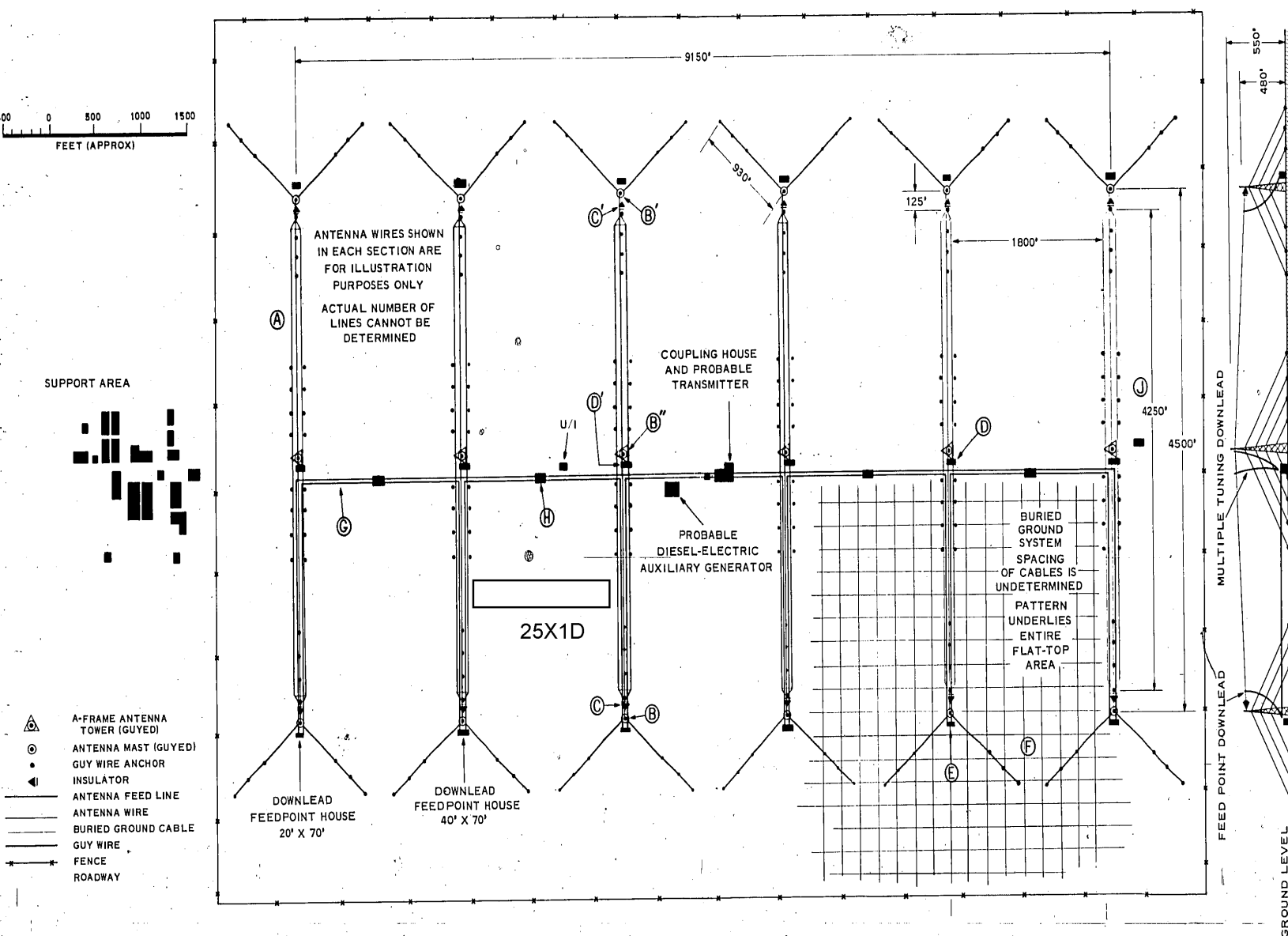
If the bent antenna were a T and were fed at the center, however, its frequency would be several times higher than that for an end-fed antenna. Actually, its frequency would be so high as to take it out of the VLF range altogether. It is believed, therefore, that the antenna is end fed and that 29 kc represents a reasonable estimate of its frequency.

- 4 -

TOP SECRET

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FIGURE 2. APPROXIMATE LAYOUT OF ANTENNA.

**TOP SECRET** 

NPIC/R-47/62

Series Tuning

It is further estimated that the antenna is series tuned. This estimate is based on engineering recommendations that, when a downlead is one-eighth of a wavelength or shorter, series tuning be utilized and if greater than one-eighth wavelength then parallel tuning be utilized.

Nature of the Terrain

The antenna is located in an area of good soil conductivity to increase its terminal efficiency to some extent and to increase the efficiency still further by proper design of the grounding system.

## CONCLUSIONS

The large cross-sectional area of this antenna, both above and below ground, suggests high capacitance and high power.

The fundamental frequency has been computed to be about 29 kc. The large cross-sectional area of the antenna, however, should give broad bandwidth.

From a radiation standpoint, the moderate height of the flattop compared with its wavelength and large surface area, and the fact that it has multiple tuning over marshy terrain, suggest a highly efficient antenna. These factors, combined with the computed frequency and a relatively nondirectional wavefront, indicate that both submarines and surface vessels of the Soviet Fleet could communicate reliably at very low frequencies over a broad expanse of the Pacific Ocean.

Except in nonsignificant aspects, there are no features of this antenna that cannot be derived from standard references on antenna design. 2/ The exact application of these principles is largely a matter of interpretation, but except for the configuration of the antenna, there is nothing unique about the Khabarovsk VLF antenna.

- 7 -

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NPIC/R-47/62

**REFERENCES****PHOTOGRAPHY**

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